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FINAL REPORT

Plowshare / peaceful uses for nuclear explosives

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project SEDAN

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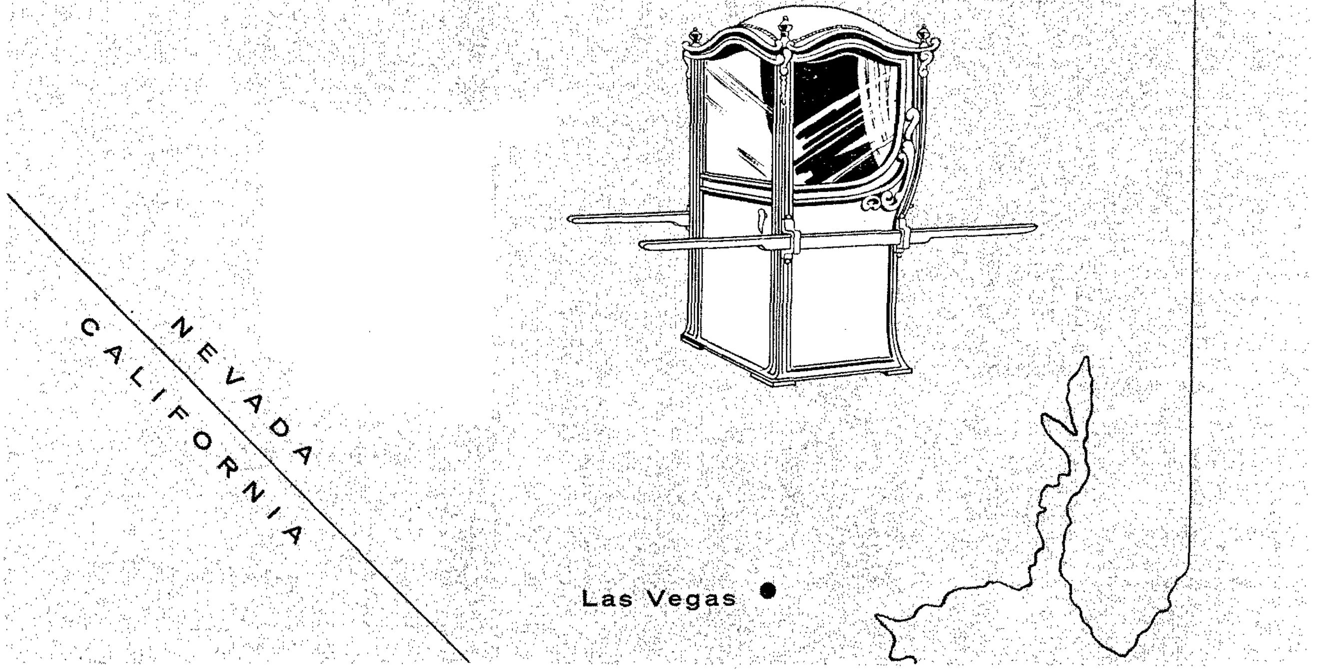

Naval Aerial Photographic Analysis

F. L. Vuillemot

Jan 63

U. S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

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PROJECT SEDAN

NUCLEAR EXPLOSIONS – PEACEFUL APPLICATIONS

PNE 230F

NAVAL AERIAL PHOTOGRAPHIC ANALYSIS

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San Francisco 24, California

January 1963

ABSTRACT

The procedures and results of extensive pre and postshot aerial photographic coverage by naval aircraft are described and evaluated. Objectives were to use high performance photo aircraft to document pre and postshot ground zero area conditions, to provide aerial photographs for immediate onsite use in operations and to determine the unique advantages, if any, of this type of photographic coverage.

One preshot and three postshot photo missions were run over the ground zero area by flights of two supersonic F8U-1P (Crusader) jet aircraft of the Pacific Fleet. During each mission, black and white, infra-red and color films were exposed. Missions were initially limited to coverage of the immediate crater area but later expanded in area to include the extensive up-wind and cross-wind base surge deposition area.

Results indicated that no particular advantage resulted from use of color and infra-red film; black and white film proved quite adequate, at least for the low color-contrast area characteristic of the Nevada Test Site. Interim photo-interpretation stereo techniques provided the initial gross crater measurements. More deliberate photogrammetric efforts were later employed to locate crater contours and vertical

profiles, relative to the bottom of the crater.

The strong correlation of the residual contamination and the highly visible up-wind and cross-wind base surge deposition area is demonstrated. The potential value of naval aerial photography in such events is discussed within the context of recent technological advances.

It is concluded that such naval aerial photographic coverage is of considerable value in the rapid assessment of the gross effects of such large scale nuclear excavation events.

PREFACE

The naval aerial photographic operations described herein were initiated by the U. S. Naval Radiological Defense Laboratory (NRDL) in response to the request of the Project SEDAN Technical Director at the Nevada Test Site. Similar aerial photographic operations were planned by NRDL for the ground zero areas of other NTS nuclear events in July, 1962. This permitted ready expansion of the effort to include the ground zero area of Project SEDAN.

The author wishes to acknowledge the large contribution of the Light Photographic Squadron - Sixty-Three (VFP-63) to this effort. Prior to and after formal approval by the Commander, Fleet Air, San Diego, the officers and enlisted men of this squadron enthusiastically participated in the hastily conceived plan and its execution. The successful results can in large measure be attributed to the continued highly professional performance of VFP-63 personnel. Especially noteworthy were the contributions of the Commanding Officer of VFP-63, CDR R. L. Clarke, USN, and the Photographic Officer of VFP-63, LCDR G. M. Dougan, USN. LTJG G. F. Cronin, USNR, provided invaluable liaison and expert assistance in the postshot photo-interpretation effort. Master Chief Petty Officer R. A. Morgan, USN, served most capably, under unique and demanding

circumstances, as the squadron representative at the Nevada Test Site.

The encouragement and support of the following organizations are noted and appreciated:

Continental Test Organization, Field Command, DASA

Civil Effects Branch, DBM, AEC

Special Projects Division, San Francisco Operation Office, AEC

Post-Attack Research Division, OCD

Fleet Air, San Diego, COMAIRPAC

U. S. Naval Photographic Interpretation Center

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INTRODUCTION

OBJECTIVES

This Project was conceived several days prior to shot date and the objectives were not formally stated. At the time of initiation of the effort it was believed that the following would be reasonable objectives:

a. To photograph pre and postshot ground zero area conditions, using high performance (supersonic jet) photo aircraft of the Pacific Fleet.

b. To provide aerial photographic coverage for immediate on-site use in evaluating postshot conditions, including crater dimensions.

c. To evaluate possible advantages of such aerial photography for use in subsequent Plowshare tests.

BACKGROUND

The U. S. Naval Radiological Defense Laboratory (NRDL) participated in a number of Projects conducted during the DOD Operation SUNBEAM series at the Nevada Test Site in the Summer of 1962. Its Military Field Operation Office (MFOO) had planned pre and postshot aerial photographic coverage of several nuclear explosion ground zero areas. The period of NRDL's planned aerial photographic operations coincided with the Project SEDAN event in early July.

In meetings at the Nevada Test Site, several days prior to shot date, it was agreed that the MFOO would undertake to provide similar aerial photographic coverage of the Project SEDAN ground zero area. NRDL requested the aerial photo support from the Commander, Fleet Air, San Diego, who promptly authorized the Light Photographic Squadron - Sixty-Three (VFP-63) to execute the desired support. Direction of the photo effort was effected by the MFOO at the Nevada Test Site. The Special Projects Division of the AEC's San Francisco Operations Office provided a fund to NRDL to defray costs of the SEDAN aerial photographic effort. During July a total of 14 missions were accomplished by VFP-63 at the Nevada Test Site in support of the MFOO. A detailed report[1] on the aerial photographic operations is under preparation by NRDL and VFP-63 and should be referred to for additional operational details not contained herein.

Aerial photography of nuclear explosion ground zero areas has been accomplished during past nuclear events at the NTS. Normally it was limited to high speed photography to record the early time phenomena of the explosion proper or to large-scale vertical coverage of craters for photogrammetric measurement of crater dimensions. Although the initial VFP-63 photo missions over Project SEDAN were limited to the immediate ground zero area, coverage was expanded in the later missions to include aerial photography of the area of base surge deposition. This base surge deposition area was highly visible to observers on the ground and in aircraft and is readily identified on the postshot aerial photographs.

PROCEDURE

PLANNING

The photo squadron, VFP-63, is based at the Naval Air Station, Miramar, near San Diego, California--about 250 nautical miles from the Nevada Test Site. This squadron flies the photo version (F8U-1P) of the Fleet's supersonic Crusader jet aircraft. It includes in its organization an extensive, permanent photo laboratory capable of processing and interpreting large quantities of aerial photographs--including color photography. Appendix A provides more detailed information on the photo aircraft, camera, and film data used in the operation.

Preliminary liaison had been effected between NRDL and VFP-63 in the spring of 1962 in anticipation of a relatively small aerial photo effort during the Small Boy event at the NTS. In late June it became evident that a large scale aerial photo effort, covering several event ground zero areas, was feasible. On 3 July 1962 liaison was effected at the NTS by VFP-63 pilots and the squadron Photo Officer with personnel of NRDL, the Continental Test Organization (CTO), and other agencies interested in the planned aerial photo missions. Problems of NTS aircraft exclusion areas, control of aircraft over the NTS and security restrictions on dissemination of the planned aerial photographs were solved by the preparation of detailed flight instructions and the initial classification of all aerial photos as Secret-RD pending evaluation by the CTO Security Officer. (All of the SEDAN aerial photographs taken by VFP-63 were later declassified to "Unclassified--For Official Use Only".)

An initial Aerial Photo Coverage Plan, Table 1, was prepared to indicate the planned coverage by VFP-63 of the Project SEDAN area. This plan provided for one preshot and one postshot mission, each by a flight of two squadron F8U-1P aircraft exposing a combination (Appendix A) of infra-red, color and black and white film. A photo mission was to be made over the ground zero area on D-1 and again at H + 6 hours on D-Day. Photography was limited to verticals only. Oblique aerial photographs were possible, but not accomplished, in order to preclude any photography of NTS exclusion areas. Flights were usually made at 8,700 feet altitude above the terrain, resulting in photo scales ranging from 1:8,500 to 1:21,000. H + 6 hours was selected as the earliest practicable time to schedule the D-Day flight. Earlier time of flight over the postshot ground zero area was possible since the altitude of the flight placed it well above other air activity but was neither necessary nor desirable. The six hour delay after shot time permitted the flight to remain at its home base through any possible shot delays on D-Day and insured its arrival over the ground zero area after other event activity had decreased.

NRDL requested the services of a squadron representative at the NTS to facilitate the aerial photo operations. On 4 July a Master Chief Petty Officer arrived for duty with the MFOO as the VFP-63 liaison officer and remained on-site for a period of three weeks. During this period he provided valuable services in the requesting of missions, the receipt and handling of photographs, and the interpretation of the photographs.

OPERATIONS

The message request for the first SEDAN aerial photo mission was prepared by the MFOO and released by the CTO early on the morning of 5 July (D-1). Direct liaison was maintained by telephone between the MFOO and the photo squadron at Miramar so that the squadron had advance notice in detail[1] of a planned mission by late evening on the night prior to the mission date. By the time the priority mission message was received by VFP-63, the flight had been equipped and briefed so that the mission message acted, in effect, as the official "GO" signal, with the two flight aircraft airborne shortly after receipt of the dispatch.

The flight pilots were required to check in and out of the NTS area by radio with "Yuletide Control", the NTS Air Traffic Coordination Center. The first two missions were as planned and limited to coverage of the immediate ground zero area of SEDAN. These same flights photographed the Small Boy and

Johnie Boy ground zero areas during each of the sorties on 5 and 6 July. On 7 July (D + 1) a special photo mission was executed to include as much of the large base surge deposition area as practicable. Again on 9 July (D + 3) large area coverage of the base surge area was accomplished, but at a larger scale in order to provide aerial photographs more suited for later interpretation of the crater and specific objects in the ground zero area. Table 2 details the photo missions accomplished over the SEDAN ground zero area and the logistic (delivery) missions of the processed photo prints to the MFOO.

The processing and delivery of such large quantities of aerial photographs posed a considerable problem to VFP-63 and was accomplished only by an all-out effort of its photo laboratory over an extended period of time. Aerial photos of SEDAN were processed and delivered concurrently with those of Small Boy and Johnie Boy. It should be noted that the processing of color photographs is much more expensive in time, effort and materials than processing either infra-red or black and white photographs. During the eleven-day period of 6 to 16 July the squadron processed and delivered a total of 3,800 individual photographs and mosaics to the MFOO at NTS. Approximately one-third of these were of the SEDAN area. The delivery method evolved to a routine wherein the pilots flying a photo mission would carry with them the completed prints prepared during the night from the previous day's photography. Upon completion of the day's mission the pilots would fly in to Nellis AFB (near Las Vegas, Nevada), transfer the photographs with classified material receipt to a waiting MFOO representative, and then promptly depart for NAS, Miramar, without shutting down the aircraft engines. This arrangement precluded the initially planned special logistic flights and greatly accelerated receipt of the photographs. The SEDAN photographs were logged in, evaluated and then forwarded to the SEDAN Technical Director upon their arrival at the NTS.

RESULTS

AERIAL PHOTOGRAPHY ACCOMPLISHED

Figures 1, 2 and 3 indicate the areas photographed with infrared, color, and black and white film respectively. Prints of each were forwarded to the SEDAN Technical Director at the NTS upon their receipt by the MFOO. These were used by the Technical Director's staff as aids in the initial assessment of the crater and the base surge deposition area. During August 1962 large quantities of these photographs were requested of NRDL by the Boeing Company for its SEDAN ejecta studies, by the AEC'S Division of Biology and Medicine, and by UCLA for evaluating the base surge area in relation to its Civil Effects Test Group projects. The Astrogeology Branch of the U. S. Geological Survey has employed the photographs in its study of the SEDAN secondary impact craters, strikingly similar to the secondary impact craters associated with craters on the Moon.

The quality of all the SEDAN photography was uniformly good. The pre and postshot aerial photographs (Figure 4) of the ground zero area provide dramatic three-dimensional (using a pocket stereoscope) evidence of the gross effects of this large cratering event. Receipt of the postshot H + 6 hours, D-Day aerial photographs on D + 1 provided the SEDAN Technical Director's staff with the first complete graphic evidence of the event. These aerial photographs aided greatly in the initial evaluation of the effects and in the postshot briefings of the SEDAN Technical Director's staff and the visiting scientists on hand for the event.

Evaluation of the three film types employed indicated no significant advantage in the use of color or infra-red film. Standard black and white film (Figure 5) appeared to be completely satisfactory for evaluation of the SEDAN postshot conditions.

All photo negatives and extra prints were retained at VFP-63 for the preparation of required reports. All negatives and extra prints will eventually be forwarded to the Field Command, DASA, as required by CTO SOP 110-1.

INTERIM CRATER ANALYSIS

Using the simple, hand-operated stereo-comparagraph equipment organic to the photo squadron, VFP-63's Photo-Interpretation Section prepared an interim SEDAN crater analysis report. This was forwarded by the MFOO to the SEDAN Technical Director on 10 July. The 1200 foot diameter and 299 foot depth measurements (± 5%) indicated therein were found to be in excellent agreement with the later measurements[2] of 1200 foot diameter and 320 foot depth. This interim crater analysis provided the first authoritative measurements of the SEDAN crater's gross dimensions.

DELIBERATE CRATER ANALYSIS

The Naval Photographic Interpretation Center (NPIC) in Suitland, Maryland prepared[3] a more deliberate crater analysis (Figure 6) of the SEDAN crater by using photogrammetric techniques. This crater analysis was prepared to determine the feasibility of such an analysis inasmuch as the task was complicated by the large size of the crater, the lack of available field-established control data and the usual unsuitability of such reconnaissance type photography for precise photogrammetric work. The crater analysis was performed on a standard "Wild" A-5 stereo-plotting instrument which provides a semi-automatic readout of elevation data from stereo-pair aerial photographs. This is a first-order photogrammetric stereo instrument, capable of deriving vertical data accuracies of plus or minus one foot with suitable cartographic photography depicting well distributed, reliable, vertical control. All control data used in the development of Figure 6 was derived solely from Project engineer drawings and U. S. Geological Survey maps.

Horizontal control was established by use of a USGS Oak Spring Quadrangle map, enlarged to a scale of 1:4,800. Identification of photographic detail of the photography covering the crater could not be accomplished from map sources. A stereo model of the area adjacent to the crater was oriented to map detail, and horizontal pass points were extended to the crater model. Exposures 152 and 153 of postshot sortie 0004 on 9 July were used in the analysis. Photographic and planimetric detail on this postshot photography had changed so radically in comparison to the preshot photography, sortie 0001, that accurate vertical information from source material could not be resolved. A relative vertical solution was derived by selecting areas which appeared to be of equal elevation. All of the contour lines (more precisely called "form" lines since they do not have reference to true elevations) were then determined from a zero elevation at the bottom of the crater. Due to the lack of control, contour lines were compiled only within the crater. The estimated horizontal error is $\pm$ 2.5 meters and the estimated vertical error is $\pm$ 0.5 meters.

Figure 7 presents three vertical profiles drawn along the N-S and E-W axes and through the collapsed portion of the lip in the NW quadrant. These profiles were drawn directly from the basic contour work (Figure 6). A more accurate profile effort would have been possible if direct elevation readings were taken along the profile lines with the stereo-plotting instrument. This additional effort was not believed warranted, however, and therefore was not requested of the NPIC.

BASE SURGE DEPOSITION AREA

A large mosaic was prepared (Figure 8) to present the assembled area coverage of Sortie 003 on 7 July (D + 1). The mosaic is uncontrolled since it was prepared without benefit of field-established control. Therefore the indicated scale is approximate only and will vary somewhat in different areas across the face of the mosaic. Such a mosaic is prepared by laying out the photographs in the sequence taken. Cutting and matching the individual photographs then results in the crude but effective over-all illustration shown in Figure 8.

The base surge which developed after the SEDAN explosion produced a heavy dust cloud which initially moved radially in all directions from ground zero. The residual mark of this base surge phenomenon is clearly evident on the photo mosaic shown in Figure 8. The light color which distinguishes the base surge deposition area is caused by mass deposition from the base surge. The deposition area evident on the mosaic coincides with that covered by the base surge immediately after the event when the rate of deposition was highest. The upwind distance of the base surge deposition area from ground zero was determined primarily by the effect of the southerly winds which arrested the upwind movement of the base surge area along the clearly visible but uneven edges of the deposition area, clearly visible as extending generally East and West in the area South (upwind) of the crater. The cross-wind distances of the deposition area edges from ground zero extend farther from the crater than does the upwind distance but are less clearly defined. The base surge area downwind (North of ground zero) indicates a more diffused deposition extending downwind for even greater distances. As might be expected, there is no visible down-wind limit to the base surge deposition area.

CORRELATION OF RESIDUAL CONTAMINATION AND BASE SURGE DEPOSITION AREA

During the development of the base surge an intimate mixing of the fission products occurs with the excavated soil. There is a direct correlation of the resulting residual contamination with the mass deposition in the ground zero area. Figure 9 indicates this correlation quite clearly by superimposing the measured residual contamination plot onto the mosaic of Figure 8. The iso-intensity contours indicated thereon were determined from ground survey measurements, all normalized to a common base time of H + 24 hours. The most significant feature of Figure 9 is the close correlation of the visible upwind and crosswind base surge deposition limits with the upwind and crosswind area limits of the residual contamination.

DISCUSSION

DOCUMENTATION

The naval aerial photographic documentation of Project SEDAN was adequate in that it demonstrated the capabilities and limitations of such coverage for large Plowshare events. The full potential value of such photography was, however, neither known nor exploited during the operations period. Figure 8 indicates the base surge deposition area quite clearly. It was prepared from the special mission coverage of 7 July which covered the largest area of any of the four missions. The ground area shown on Figure 8 is approximately 10 x 12 miles. Ideally this largest coverage should have been extended to a greater East-West coverage of 12 x 12 miles, to insure that all of the base surge area was included.

Considering the 12 x 12 mile coverage as optimum this area should have been included in the preshot and immediate postshot (H + 6 hours) aerial photographic coverage. This would have provided the best comparative coverage, especially if each mission had been flown under identical equipment, flight and time conditions in order to minimize the variables and accentuate the changes due solely to the explosion effects. This was not possible during the D-1 and D-Day coverage of SEDAN where the coverage was limited by the requirement that a single flight of aircraft photograph the ground zero areas of events Johnie Boy and Small Boy, as well as SEDAN.

The full spectrum of photo scales obtainable with such photo aircraft was not exploited. Most of the coverage was at scales ranging only from 1:8,500 to 1:10,700. Although this is a convenient and conventional scale range, varying the aircraft altitude and/or camera focal lengths can produce a much wider range of scales (e.g. from 1:5,000 for detailed interpretation to 1:60,000 for photographing the entire event base surge deposition area on a single print or two).

The reconnaissance type naval aerial photography executed during Project SEDAN is limited in that its quality is inherently inadequate for high order photogrammetric work. The large A3D-2P naval photo aircraft (Appendix A) is equipped for such precision aerial photography. In one of the recent Pacific tests of the Dominic series, such A3D-2P aircraft were effectively employed for vertical area coverage, also R5D transport aircraft rigged with special camera platforms orbited over the surface zero area to obtain complete high altitude coverage of the events with motion picture and still photography. Such coverage would provide more complete documentation then was obtained during Project SEDAN.

The standard black and white and infra-red aerial photographic films (Appendix A) appear to provide adequate quality for the

Project SEDAN coverage accomplished. No apparent extra technical benefit resulted from the use of color film (nor in the camouflage detection film used in other event coverage at the NTS). The color contrast, however, of NTS terrain is poor, presenting a uniformly light colored aspect. The use of such special films may be of advantage in assessing base surge area deposition in vegetation-covered terrain where even a light dusting on the vegetation should be readily discernible.

OPERATIONAL USE OF AERIAL PHOTOGRAPHS

The prompt delivery of the aerial photographs to the SEDAN technical staff at the Nevada Test Site was of considerable benefit. Use of these photographs was hindered by the classification label of Secret-Restricted Data. This classification was unavoidable at the time because of the CTO security requirements. It is believed, however, that this will be neither required nor desired in future Plowshare events. Such high classification greatly complicates the processing of the film and prints by the squadron laboratory.

Use of a squadron liaison officer at the test site is believed most desirable. Such an individual provides valuable assistance in requesting photo missions, advising on squadron capabilities, receiving and filing aerial photographs, and interpreting photographs for specific information. With minimum equipment such an individual can readily provide interim measurements of horizontal and vertical dimensions (e.g. apparent diameter and depth of craters) of objects visible on aerial photographs to an accuracy within ± 5%. On-site fabrication of aerial photo mosaics from separate prints is also feasible.

The squadron photographic laboratory is equipped with high speed processing equipment which is essential to prompt and efficient development of the film and the production of the initial large quantities of prints. Later needs invariably develop for additional prints for special purposes and distribution to technical personnel or news media. At the Nevada Test Site the photo laboratory at Camp Mercury could handle such special needs more conveniently than can the photo squadron at NAS, Miramar. In future Plowshare events it would again be desirable for the squadron to develop the film and process an initial quantity of prints after the photo mission. Both film and prints should then be delivered to the Nevada Test Site so that the negative films will be readily available for use, if required.

POTENTIAL VALUE OF NAVAL AERIAL PHOTOGRAPHY IN PLOWSHARE EVENTS

It is believed that the use of naval aerial photography has a number of distinct advantages in the documentation and assessment of Plowshare events. The naval photo squadrons are well distributed geographically. Aircraft carrier detachments of these squadrons are capable of readily extending the operating ranges of these photo aircraft to include essentially all areas of the world where Plowshare events are now envisaged. Each of the Navy's attack carriers includes such a detachment in its normal complement and is also equipped with a complete aerial photo laboratory for high speed processing of large quantities of aerial photographs. Use of the A3D-2P photo aircraft can provide precision aerial photography for cartographic work.

For the large scale Plowshare events envisioned, aerial photography provides the only feasible method for documentation and assessment of the pre and postshot conditions of the extensive event areas. Field-established control in the event areas will permit production of accurate pre and postshot topographic maps at a variety of scales. Such extensive aerial photographic efforts may well be beyond the capabilities of commercial aerial survey companies because of the remoteness of the event areas and the large backup of alternate pilots and aircraft required to insure timely aerial photography. Such Plowshare events will be of international interest and the rapid procurement and technical evaluation of the aerial photographs will be of great value in the early release of photographs and event information to the news media.

Comparative ("before" and "after") aerial photography of Plowshare events can provide much information of value to the technical staff. Using field-established control, large scale topographic maps can be prepared to accurately depict before and after site conditions. For example, the depth of throwout and base surge deposition can be quite accurately determined over large areas. Crater dimensions and contours can be precisely determined.

Much desirable information can be made available within several hours after a Plowshare event. Figure 10 illustrates the type of Photo Interpretation Report which can be generated by a photo squadron within several hours after receipt of the first postshot aerial photography. It is a hypothetical report based on the SEDAN photographs. It provides interim measurements of the crater dimensions, locates the upwind and crosswind areas of base surge deposition (identical with the area of high residual contamination), indicates the close-in direction of the "hot line" (the downwind direction of the fallout), and provide an excellent graphic illustration of the postshot site conditions.

Many agencies of government and industry are continuously advancing the "state of the art" of aerial photographic interpretation in the many areas of techniques and equipment. A recent comprehensive study [4] of the current state of such interpretation is included in the work by the Stanford Research Institute in support of the Vela Uniform Program of the Advanced Research Projects Agency of the Department of Defense. This particular aspect of the work is primarily directed toward the development of effective aerial photographic techniques to aid in the on-site inspection of unidentified seismic events (i.e. earthquakes and underground explosions, both nuclear and non-nuclear).

A more recent report [5] has been published on the progress of Itek Laboratories in its development of an Airborne Spectral Reconnaissance System for Detection of Underground Nuclear Explosions--alsc in support of ARPA'S Vela Uniform Program. The System has been developed and is now undergoing operational tests. Consisting of a rather extensive array of airborne sensors, it is designed to detect and record the surface manifestations of underground explosion (e.g. small fissures, vegetation and soil changes). The sensors include cameras and spectrometers to record specific bands of reflected light in the spectrum from 0.5 to 5.0 microns (visible through infra-red). The demonstrated characteristic reflectance "signatures" of photographed surfaces (e.g. grass, soil, asphalt, trees) is being investigated with the idea of then being able to rapidly detect and assess any changes, caused by underground nuclear explosions, in these normal "signatures". One such technique is the detection of dust on plants, possible because of the changes in the reflected "signature" of the "dusted" plant surface as contrasted to the normal reflected "signature" of the plant. One possible application of this technique to Plowshare events would be in the rapid detection and graphic portrayal of the deposited soil from the excavation. Ordinary aerial photographic film can now easily detect (Figure 10) the grosser thicknesses of mass deposition. The less visible deposition is also significant because of its correlation with the lower levels of residual radioactive contamination from the event. Such an airborne spectral reconnaissance effort (perhaps limited to the relatively simple nine-lens spectral camera [5]) should permit rapid graphical determination of the extents of the less visible deposition area by detecting the "dust" on grasses, trees, roads, and on snow and ice in the case of more Northern Plowshare events. The net effect would be to greatly extend the soil deposition assessment capabilities of aerial photographs to include the more distant (from ground zero) areas, where reliance is now placed on aerial and ground surveys--both with radiacs which require extensive correlation and plotting effort.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Pre and postshot aerial photography of the crater and surrounding area can be successfully accomplished by naval photographic aircraft using a variety of film types.

Aerial photographs, photo mosaics and interim crater analyses can be prepared for on-site use immediately following the event.

The reconnaissance type photography accomplished has inherent technical limitations which preclude the preparation of controlled photo mosaics and of crater analyses with the accuracy possible with the use of larger and more stable aircraft such as the A3D-2P. Adequate ground control data must be available for these more deliberate efforts.

The location, organization and equipment of Light Photographic Squadron Sixty-three are well suited to the accomplishment of a wide variety of aerial photographic missions at the Nevada Test Site. Proper on-site liaison insures a rapid response to changing requirements which develop during test operations. The similar aerial photographic capabilities which exist on Navy attack aircraft carriers can conceivably be employed to extend such support to Plowshare event sites outside of the continental United States.

Extended aerial photographic coverage of the area surrounding the ground zero can be used for rapid, expedient assessment of the gross residual effects of the event, to include the residual contamination as delineated by the base surge deposition area.

Recent advances in the "state of the art" of aerial photographic interpretation indicates developments of possible future application in Plowshare events.

RECOMMENDATIONS

In future Plowshare events, consideration should be given to obtaining extensive pre and postshot area coverage by naval photographic aircraft.

The potential values of aerial photographic analysis should be continuously examined to ensure that maximum use is made of its unique capabilities in the Plowshare Program.

APPENDIX A

AIRCRAFT, CAMERA AND FILM DATA

1. AIRCRAFT

The RF-8A (formerly designated the F8U-1P) is the photographic version of the F-8A Crusader, a jet fighter now in Navy and Marine Fleet aircraft units. It is stripped of weapons and armor to make it a single purpose, long range and high speed (supersonic) aircraft capable of taking vertical and oblique aerial photographs from a number of camera installations on the bottom and sides of the aircraft. In the Fleet Marine Force this aircraft is assigned to the Marine Composite Reconnaissance Squadrons found in each Marine Air Wing. In Navy aviation units this aircraft is found in the Light Photographic Squadrons—one located on each coast of the United States, under Commander Naval Air Force, Pacific and Commander Naval Air Force, Atlantic. These Light Photographic Squadrons each provide aerial photographic detachments (aircraft and personnel) for each attack carrier of the fleet and maintain extensive training and laboratory facilities.

In addition to the Light Photographic Squadrons (VFP), there are two Navy Heavy Photographic Squadrons (VAP), one on the East coast and one on the West coast, equipped with the heavier, longer ranged RA-3B (formerly designated the A3D-2P), the photo version of the Douglas RA-3A Sky Warrior twin-jet attack aircraft. The photographic equipment in the RA-3B is essentially the same as in the smaller RF-8A but the larger aircraft provides for a more varied and larger size camera configuration and a more stable platform for Cartographic Photography.

2. CAMERAS

The full photo capability of the F8U-1P was not utilized in the NTS operations because of the decision to limit the photography to vertical coverage only. The following is a representative camera installation used during the NTS operation except that in the photography of Project SEDAN, Camera #5 was loaded with infrared film. The three vertical stations on each of the two aircrafts were loaded as indicated so that a total of six cameras with four film types were exposed during each mission.

AIRCRAFT NUMBER ONE

	Camera #1	Camera #2	Camera #3
Type:	CAX-12, 3" Focal Length	K-17, 6" F.L.	KA-40, 3" F.L.
Film:	Black and White	Infrared	Color Negative
Size:	70mm (2 1/4"x2 1/4"x100')	9"x9"x75'	4 1/2"x4 1/2"x40'
Print Size:	9"x9"	9"x9"	8"x10"

AIRCRAFT NUMBER TWO

	Camera #4	Camera #5	Camera #6
Type:	CAX-12, 3" Focal Length	K-17, 6" F.L.	K-17, 6" F.L.
Film:	Color Negative	Camouflage Detection	Black & White
Size:	70mm (2 1/4"x2 1/4"x100')	9"x9"x75'	9"x9"x180'
Print Size:	8"x10"	None	9"x9"

The above installation is based on using the black and white film in #6 as the standard for comparison with the color, infrared and camouflage detection film. Cameras #3 and #6 are considered primary, with #2 and #5 providing supplemental coverage and #1 and

#4 providing back-up. If all systems in both aircrafts worked, the film from cameras #1 and #4 were not printed as all other stations would have better coverage. All black and white negatives were printed to 9" X 9" format. Color negatives were enlarged and printed on 8" X 10" paper stock which was the only size available. This in effect reduced the forward overlap to 50%.

3. FILM

Camouflage detection film was not employed during the aerial photography of Project SEDAN but was used in subsequent missions at the NTS. The camouflage detection film is a color positive film having an infra-red emulsion layer film with a capability to detect a change in chlorophyll content of vegetation. For example, tree branches cut and used for camouflage of buildings are readily detected as such, for their chlorophyll content decrease is rapid and in image contrast with the surrounding vegetation as seen on the camouflage detection film. Camouflage detection film is intended for direct viewing as transparencies; therefore, no prints are made.

Aerial color photography cannot be depended upon to give consistent or true color rendition. Color photography is a "corrective" process where, through the aid of color printing filters, the color rendition is corrected to provide a print that is: (a) pleasing to the viewer, or (b) "true" in the opinion of the technician based on what he supposes the subject color was, or (c) balanced for actual colors by including in the area a "color scale" or a "neutral card" of known values. By processing and adding or subtracting color through special filters during printing, the known values are printed to match a "standard" and it may then be assumed that the overall scene has a true color balance. This last procedure is only practical in a laboratory or for ground photography under controlled conditions but is totally impractical for aerial photography. Aerial color prints are normally used as comparison photos and do not lend themselves to assemble into a photo mosaic map substitute. It is possible to assemble two or three adjoining prints but the scale change caused by the shrinkage and distortion of color stock over a number of color prints becomes too great for any degree of accuracy.

Infra-red film looks like and is processed like ordinary black and white film. The principal difference is that the infra-red film is more sensitive to the longer wave length of light in the infra-red portion of the emitted spectrum. This infra-red emission from practically all visible objects has a better haze penetration capability than the shorter wave-length emissions. In operational use, the infra-red film is often used to penetrate the atmospheric haze usually encountered in aerial photography from high altitude. It does <u>not</u> penetrate visible moisture clouds or dust clouds any better than does black and white photography.

Black and white film is the standard and preferred film for aerial photograph work in normal operations. Photo-interpreters prefer it because of its high image quality and small grain size. It is also the least expensive of the film types.

REFERENCES

1. F. L. Vuillemot, Major, USMC; "Evaluation of Aerial Photographic Operations and Surface Markings of Nuclear Explosions, Nevada Test Site, 1962"; (In preparation); U. S. Naval Radiological Defense Laboratory, San Francisco, California; Unclassified - For Official Use Only.

2. FC, DASA; "Peaceful Uses of Nuclear Explosions"; 1 Sep 1962; Unclassified.

3. CO, U. S. Naval Photographic Interpretation Center, Suitland, Maryland; Letter to: CO, Light Photographic Squadron Sixty-three, NAS Miramar, California; Serial 0743; Subject: "Analysis of Aerial Photographs; forwarding of" (U); 26 Sep 1962; Confidential FRD.

4. R. M. Foose and others; "Manual of On-Site Inspection of Unidentified Sesmic Events"; Stanford Research Institute, Menlo Park, California; 30 June 1961; Unclassified.

5. "Vela Uniform Program, Semi-Annual Technical Report Number 1, November 1961 through April 1962"; Itek Laboratories, Palo Alto, California; 31 May 1962; Unclassified.

TABLE 1. AERIAL PHOTO COVERAGE PLAN - 3 July 62[a]

A. PLANNED AERIAL PHOTO MISSIONS - PROJECT SEDAN

Mission Number	Date	Time	Description
M2	5 July 62	1100T	SEDAN - Strip coverage; 1.5 x 3.0 miles; Black and White, and Color film; Scale 1:10,000
M4	D-Day (6 July 62)	1600T (tentative)	SEDAN - Strip coverage; 1.5 x 3.0 miles; Black and White, Color and Infra-red film; Scale 1:10,000

B. PHOTO LOGISTIC MISSIONS - PROJECT SEDAN

Logistic Number	Date	Time	Photos of Mission No.	Remarks
L 1	6 July 62	1600T	M2	Three sets Black and White prints, by Fleet aircraft to Indian Springs AFB by 1600T
L 2	D + 1	1100T	M4	Three sets Black and White, one set Color and one set Infra-red photos to Indian Springs AFB by 1100T

a. Extracted from complete Aerial Photo Coverage Plan[1]

TABLE 2. AERIAL PHOTOGRAPHIC OPERATIONS SUMMARY[a]

A. AERIAL PHOTO MISSIONS BY VFP-63, PROJECT SEDAN

Sortie Number	Date	Time	Scale (approx)	Film Type: Black and White	Film Type: Infra-Red	Film Type: Color
001	5 July 1962 (D-1)	1205T	1:8,700	X	X	X
002	6 July 1962 (D-Day)	1615T	1:8,700	X	X	X
003	7 July 1962 (D + 1)	1125T	1:10,700	X	X	X
004	9 July 1962 (D + 3)	1020T	1:8,500	X	X	X

B. AERIAL PHOTO LOGISTIC (DELIVERY) MISSIONS

Sortie Number	Date Delivered	Delivered to MFOO at	Sets of Prints Delivered: Black & White	Sets of Prints Delivered: Infra-Red	Sets of Prints Delivered: Color	Remarks
001	6 July 62	Nellis AFB	3	3	2	
002	7 July 62	Nellis AFB	3	1	1	
003	9 July 62	Nellis AFB		3	1	Black and White Camera failure
004	10 July 62	Indian Springs AFB	3	1	1	

a. Extracted from complete Aerial Photographic Operations Summary[1]

Organization: VFP-63
Map Reference: Series V502, Sheet NJ 11-8, Edition 3, AMS
Geo. Ref: Nevada Test Site-Project Sedan

1. Sortie: 0001
Date: 5 July 1962
Time: 1205 T
Focal Length: 12"
Altitude: 8,700'
Scale: 1:8,700
Exposures: V052-V056

2. Sortie: 0002
Date: 6 July 1962
Time: 1615 T
Focal Length: 12"
Altitude: 8,700'
Scale: 1:8,700
Exposures: V001-V12

3. Sortie: 0003
Date: 7 July 1962
Time: 1125 T
Focal Length: 12"
Altitude: 10,700'
Scale: 1:10,700
Exposures: V001-V077

4. Sortie: 0004
Date: 9 July 1962
Time: 1020 T
Focal Length: 12"
Altitude: 8,500'
Scale: 1:8,500
Exposures: V001-V040

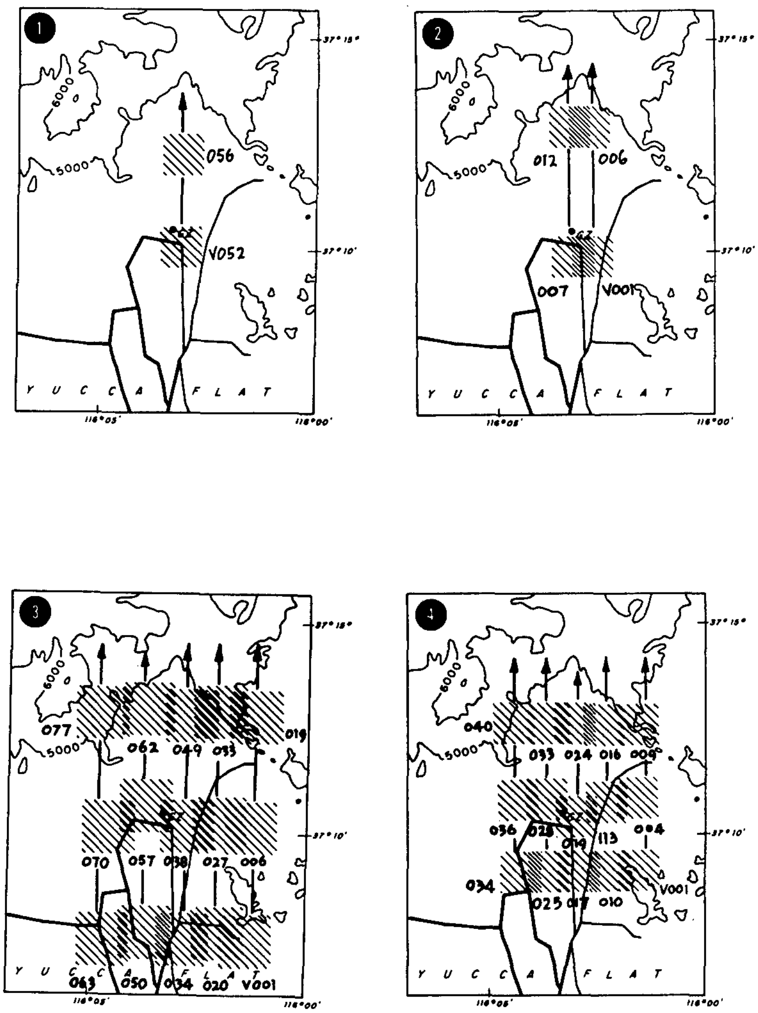


Figure 1. Infra-red Film, Plots of Aerial Photographs

Organization: VFP-63
Map Reference: Series V502, Sheet NJ 11-8, Edition 3, AMS
Geo. Ref.: Nevada Test Site-Project Sedan

1. Sortie: 0001
   Date: 5 July 1962
   Time: 1205 T
   Focal Length: 6"
   Altitude: 8,700'
   Scale: 1:17,400
   Exposures: V161-V165

2. Sortie: 0002
   Date: 6 July 1962
   Time: 1615 T
   Focal Length: 6"
   Altitude: 8,700'
   Scale: 1:17,400
   Exposures: V001-V005

3. Sortie: 0003
   Date: 7 July 1962
   Time: 1125 T
   Focal Length: 6"
   Altitude: 10,700'
   Scale: 1:21,400
   Exposures: V001-V136

4. Sortie: 0004
   Date: 9 July 1962
   Time: 1020 T
   Focal Length: 6"
   Altitude: 8,500'
   Scale: 1:17,000
   Exposures: V073-V122

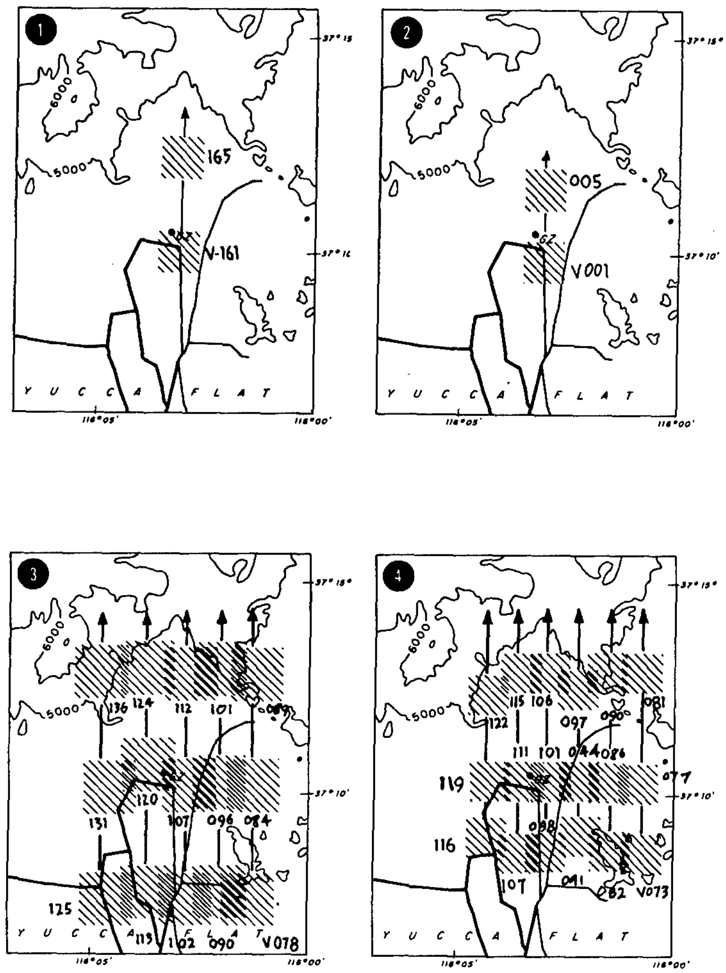


Figure 2. Color Film, Plots of Aerial Photographs

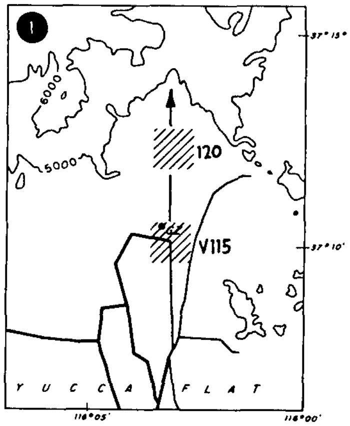
<u>Organization</u>: VFP-63
<u>Map Reference</u>: Series V502, Sheet NJ 11-8, Edition 3, AMS
<u>Geo. Ref.</u>: Nevada Test Site-Project Sedan

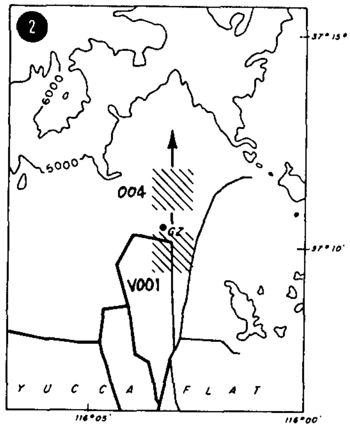
1. <u>Sortie</u>: 0001
   <u>Date</u>: 5 July 1962
   <u>Time</u>: 1205 T
   <u>Focal Length</u>: 12"
   <u>Altitude</u>: 8,700'
   <u>Scale</u>: 1:8,700'
   <u>Exposures</u>: V115-V120

2. <u>Sortie</u>: 0002
   <u>Date</u>: 6 July 1962
   <u>Time</u>: 1615 T
   <u>Focal Length</u>: 12"
   <u>Altitude</u>: 8,700'
   <u>Scale</u>: 1:8,700'
   <u>Exposures</u>: V001-V004

3. <u>Sortie</u>: 0003
   <u>Date</u>: 7 July 1962
   <u>Time</u>: 1125 T
   <u>Focal Length</u>: Camera Failure
   <u>Altitude</u>: "
   <u>Scale</u>: "
   <u>Exposures</u>: "

4. <u>Sortie</u>: 0004
   <u>Date</u>: 9 July 1962
   <u>Time</u>: 1020 T
   <u>Focal Length</u>: 12"
   <u>Altitude</u>: 9,700'
   <u>Scale</u>: 1:9,700'
   <u>Exposures</u>: V123-V179





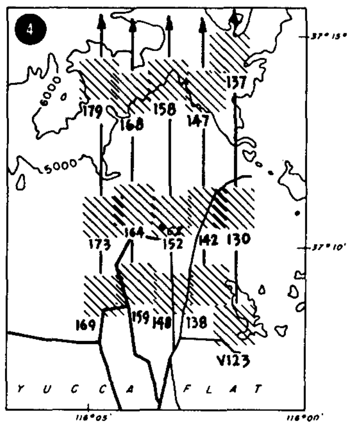


Figure 3. Black and White Film, Plots of Aerial Photographs

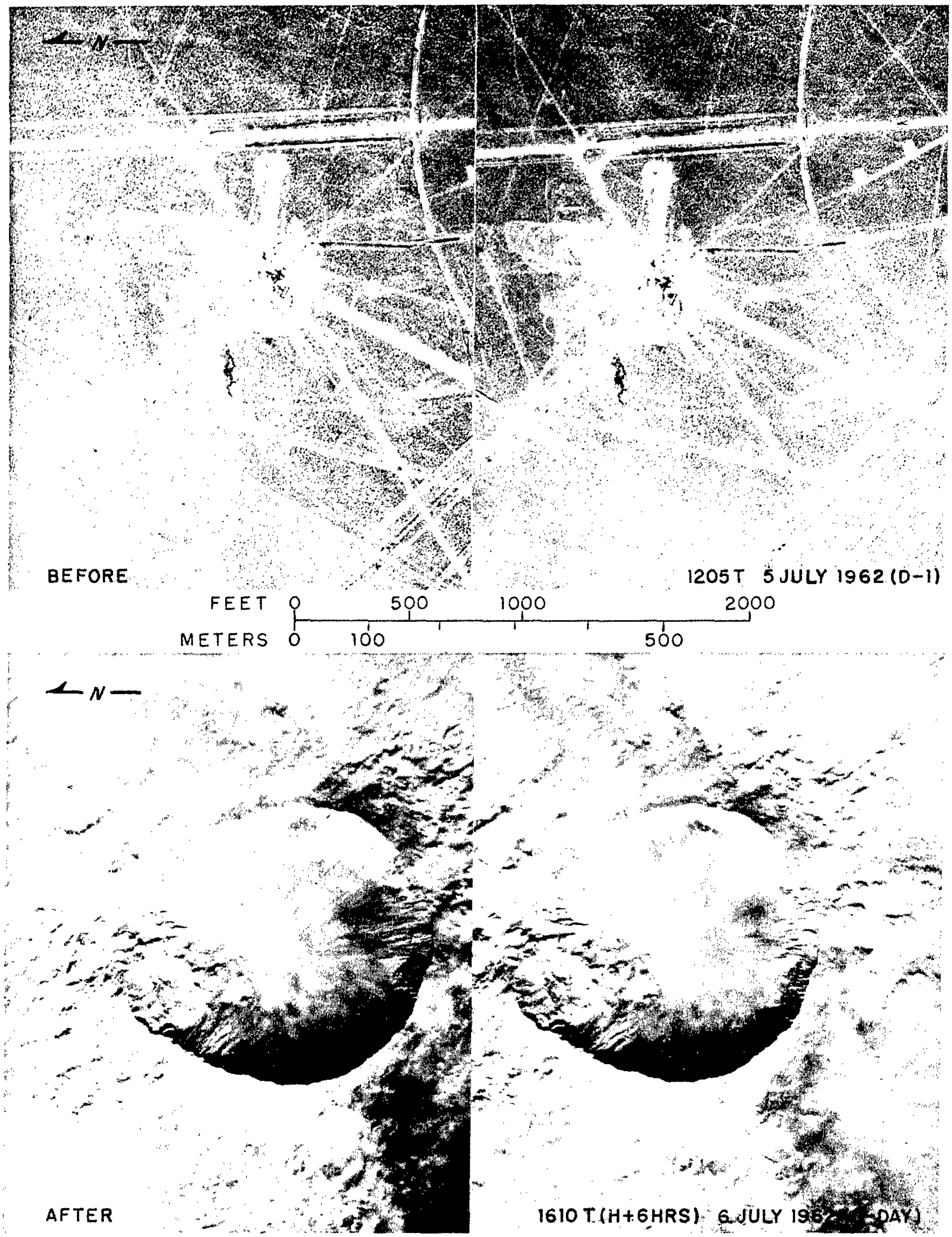


Figure 4. Stereo Views, Project SEDAN ground zero conditions - pre and postshot.

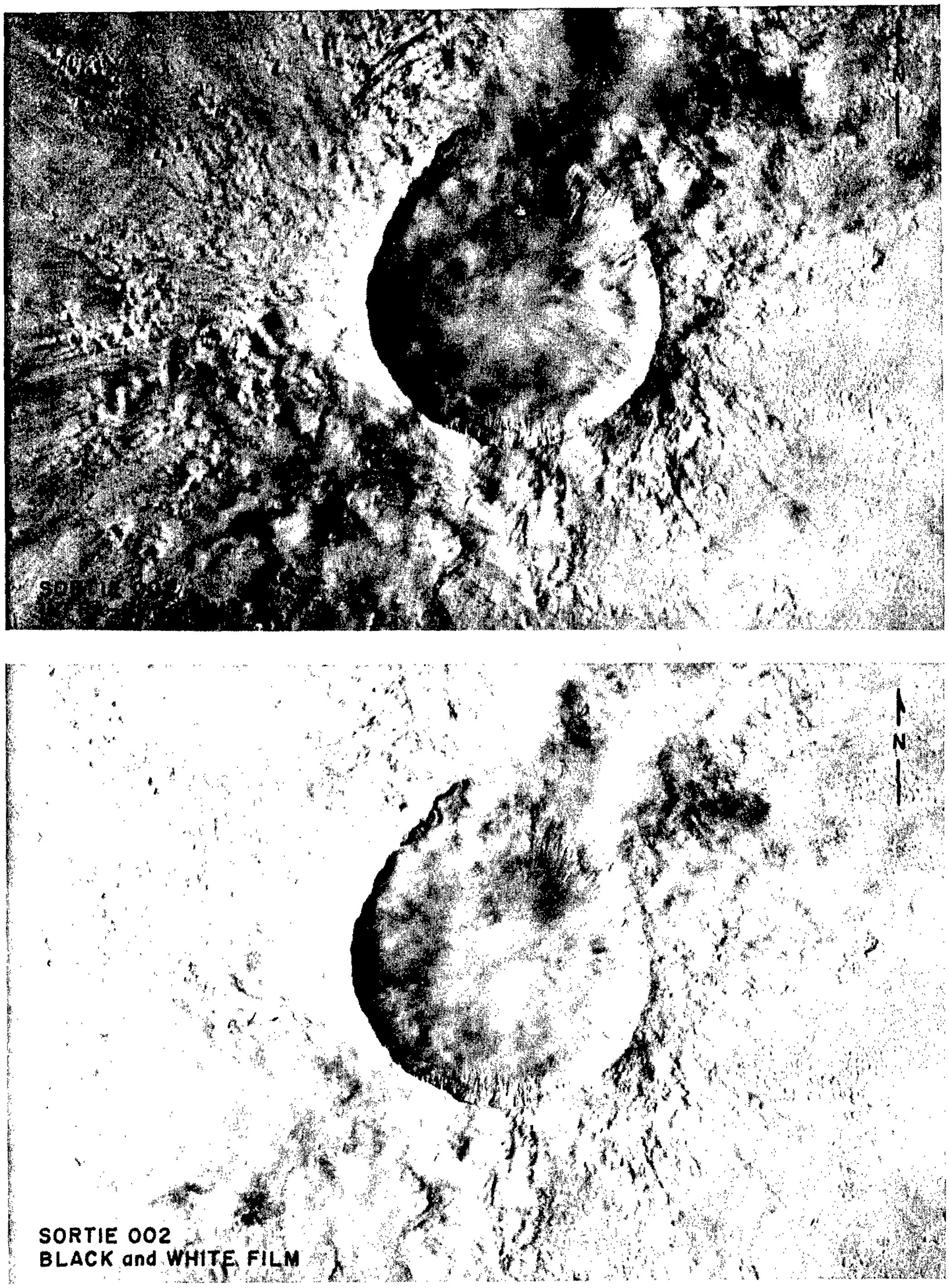


Figure 5. Comparison of Film Types.

CONTOUR INTERVAL TWENTY METERS, EXCEPT AS NOTED.
DATUM IS BOTTOM OF CRATER.

Figure 6. Crater Contours.

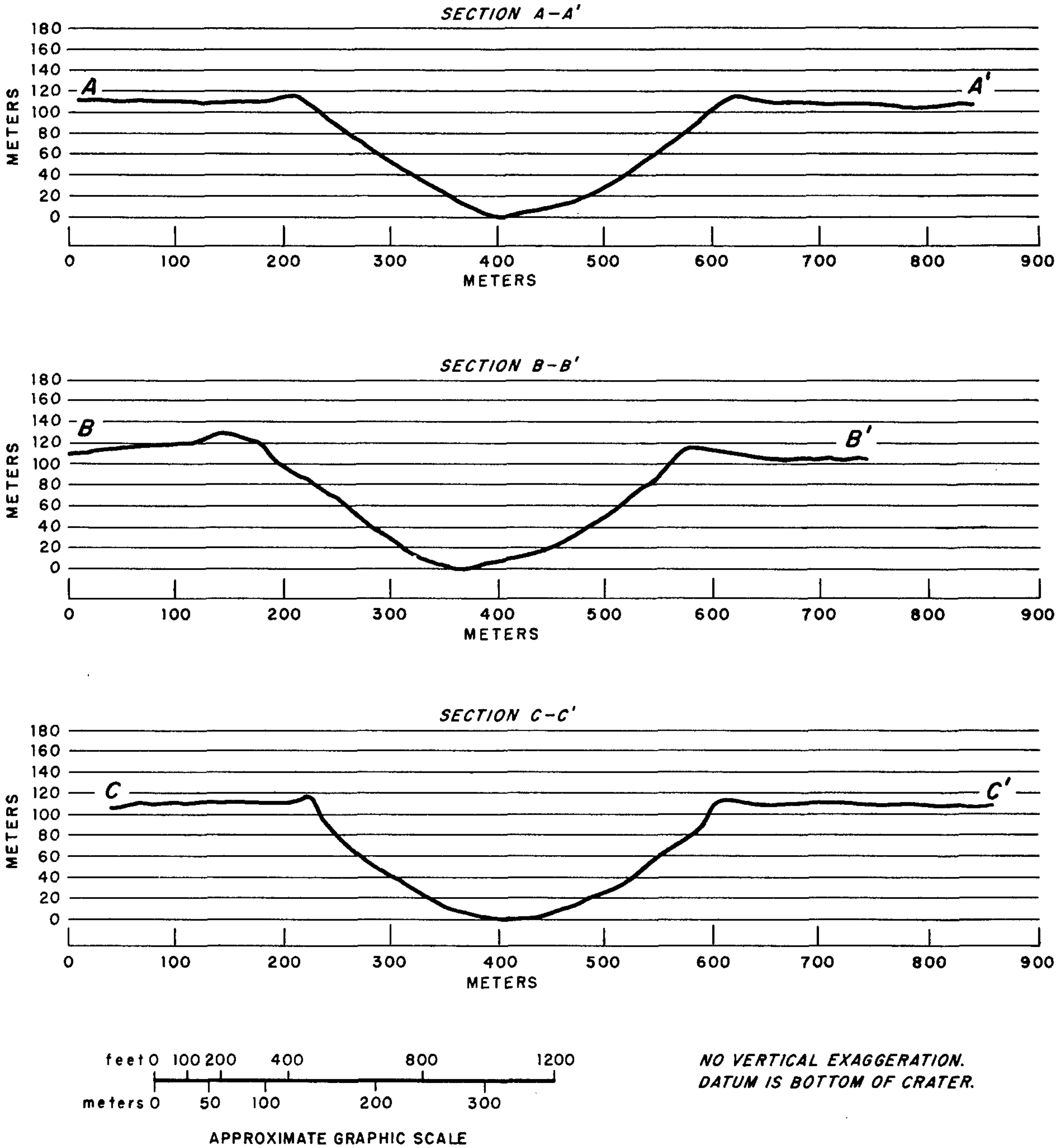


Figure 7. Crater Profiles.

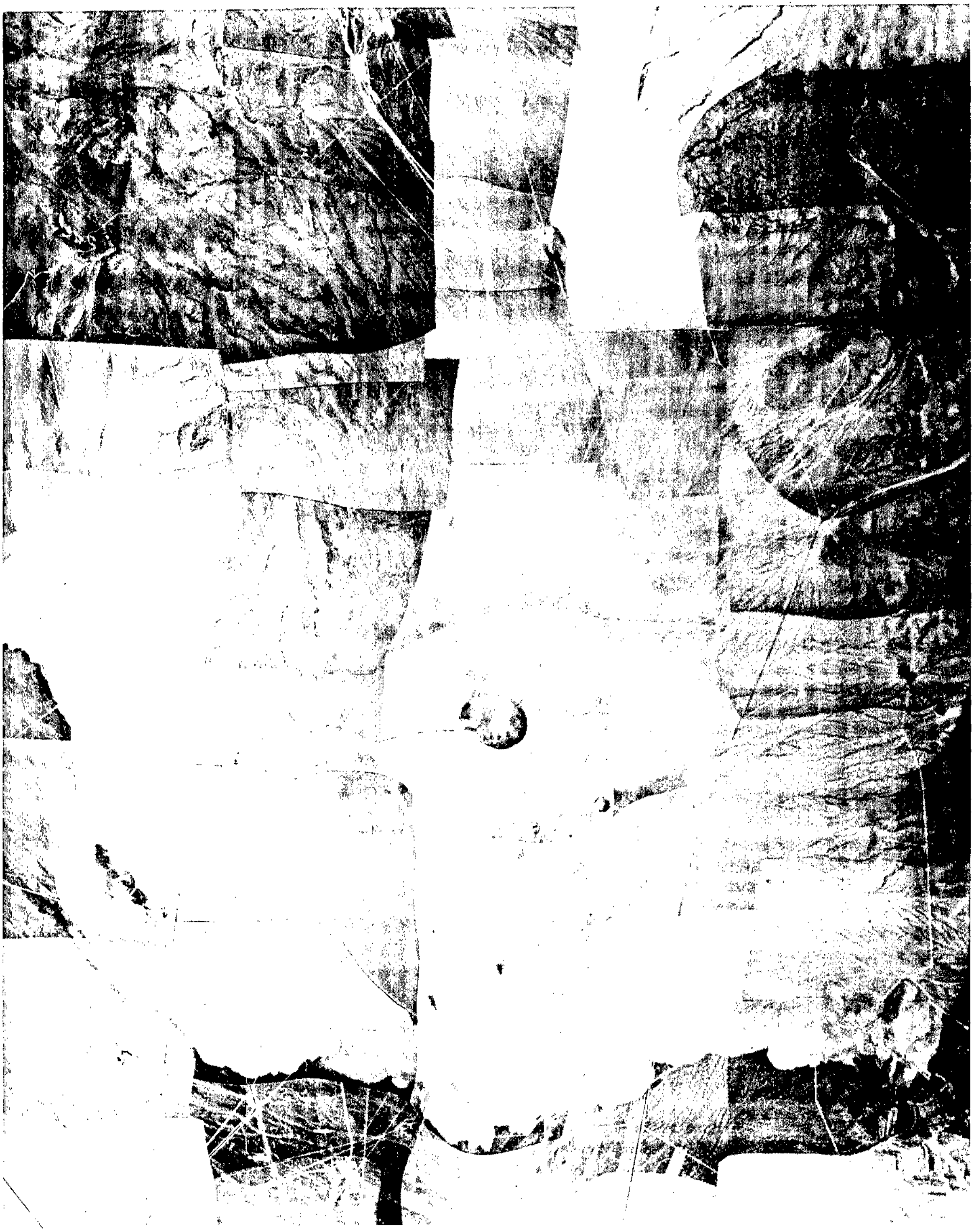


Figure 8. Mosaic of Base Surge Deposition Area.

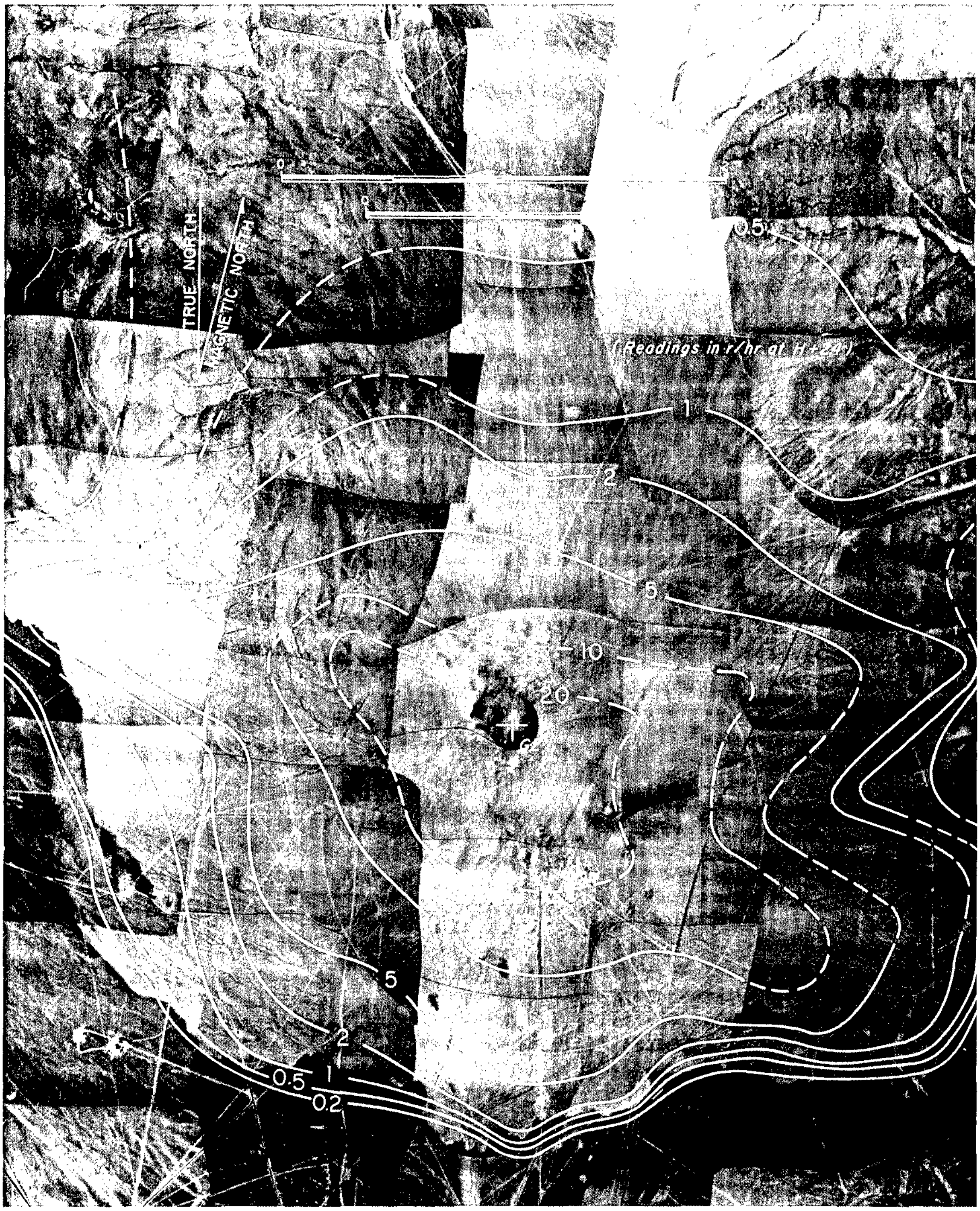


Figure 9. Mosaic of Base Surge Deposition Area and Residual Contamination Pattern

Figure 10. Mosaic of Photo Interpretation Report (Example)

TECHNICAL REPORTS SCHEDULED FOR ISSUANCE BY AGENCIES PARTICIPATING IN PROJECT SEDAN

AEC REPORTS

AGENCY	PNE NO.	SUBJECT OR TITLE
USPHS	200F	Off-Site Radiation Safety
USWB	201F	Analysis of Weather and Surface Radiation Data
SC	202F	Long Range Blast Propagation
REECO	203F	On-Site Rad-Safe
AEC/USBM	204F	Structural Survey of Private Mining Operations
FAA	205F	Airspace Closure
SC	211F	Close-In Air Blast From a Nuclear Event in NTS Desert Alluvium
LRL-N	212P	Scientific Photo
LRL	214P	Fallout Studies
LRL	215F	Structure Response
LRL	216P	Crater Measurements
Boeing	217P	Ejecta Studies
LRL	218P	Radioactive Pellets
USGS	219F	Hydrologic Effects, Distance Coefficients
USGS	221P	Infiltration Rates Pre and Post Shot
UCLA	224P	Influences of a Cratering Device on Close-In Populations of Lizards
UCLA	225P Pt. I and II	Fallout Characteristics

TECHNICAL REPORTS SCHEDULED FOR ISSUANCE BY AGENCIES PARTICIPATING IN PROJECT SEDAN

AGENCY	PNE NO.	SUBJECT OR TITLE
BYU	226P	Close-In Effects of a Subsurface Nuclear Detonation on Small Mammals and Selected Invertabrates
UCLA	228P	Ecological Effects
LRL	231F	Rad-Chem Analysis
LRL	232P	Yield Measurements
EGG	233P	Timing and Firing
WES	234P	Stability of Cratered Slopes
LRL	235F	Seismic Velocity Studies

DOD REPORTS

AGENCY	PNE NO.	SUBJECT OR TITLE
USC-GS	213P	"Seismic Effects From a High Yield Nuclear Cratering Experiment in Desert Alluvium"
NRDL	229P	"Some Radiochemical and Physical Measurements of Debris from an Underground Nuclear Explosion"
NRDL	230P	Naval Aerial Photographic Analysis

ABBREVIATIONS FOR TECHNICAL AGENCIES

STL	Space Technology Laboratories, Inc., Redondo Beach, Calif.
SC	Sandia Corporation, Sandia Base, Albuquerque, New Mexico
USC&GS	U. S. Coast and Geodetic Survey, San Francisco, California
LRL	Lawrence Radiation Laboratory, Livermore, California
LRL-N	Lawrence Radiation Laboratory, Mercury, Nevada
Boeing	The Boeing Company, Aero-Space Division, Seattle 24, Washington
USGS	Geological Survey, Denver, Colorado, Menlo Park, Calif., and Vicksburg, Mississippi
WES	USA Corps of Engineers, Waterways Experiment Station, Jackson, Mississippi
EGG	Edgerton, Germeshausen, and Grier, Inc., Las Vegas, Nevada, Santa Barbara, Calif., and Boston, Massachusetts
BYU	Brigham Young University, Provo, Utah
UCLA	UCLA School of Medicine, Dept. of Biophysics and Nuclear Medicine, Los Angeles, Calif.
NRDL	Naval Radiological Defense Laboratory, Hunters Point, Calif.
USPHS	U. S. Public Health Service, Las Vegas, Nevada
USWB	U. S. Weather Bureau, Las Vegas, Nevada
USBM	U. S. Bureau of Mines, Washington, D. C.
FAA	Federal Aviation Agency, Salt Lake City, Utah
REECO	Reynolds Electrical and Engineering Co., Las Vegas, Nevada

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